FEDERAL AID IN SPORT FISH RESTORATION

Northern Cook Inlet Chinook and Coho Salmon Enhancement

by
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RESEARCH PROJECT SEGMENT

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ABSTRACT

The Knik Arm drainages of Cottonwood Creek, Fish Creek, and Little Susitna River were respectively stocked with 316,000, 2,355,000, and 316,000 coho salmon, *Oncorhynchus kisutch* (Walbaum), fingerlings weighing 0.9 to 1.5 g. In the Little Susitna River drainage, 474,706 coho salmon smolts were released into Nancy Lake, representing an approximate eight-fold increase to the numbers of smolts released there in 1985.

Recovery of marked adult coho salmon from the Little Susitna River indicates an estimated 4% hatchery contribution to an 11,000 fish return. At Big Lake, the estimated hatchery contribution is 86%. Smolt studies indicate hatchery-produced coho salmon will contribute 36% and 100% of the adult return to Big Lake and Nancy Lake, respectively.

Willow Creek was stocked with 325,000 chinook salmon, *O. tshawytscha* (Walbaum), smolts that will return as adults between 1987 and 1990. In 1986 an estimated 72% of the age-1.1 and 0.1 "jacks" caught in Deception Creek (a tributary to Willow Creek) were of hatchery origin.

Experimental results indicate the cooling of chinook salmon eggs shortly after fertilization by adjusting water temperatures from 12° to 15°C to 3.5° to 5°C, will increase the survival rate from the 80% previously experienced to 95%.

Samples for pathological screening to establish a disease history for prospective brood sources were collected from Alexander Creek, Montana Creek, and the Little Susitna River for chinook salmon and Willow Creek for coho salmon.

Key Words: Salmon enhancement, northern Cook Inlet, brood stock development, salmon survival, sport fishing enhancement

INTRODUCTION

Alaska's sport fishing population is a highly mobile group; the majority of people live in and around the Anchorage and Matanuska-Susitna River Valley areas. Correspondingly, the most intensely fished areas of the state are those within a 2-hour drive from these major population centers; i.e., waters of the Kenai Peninsula, Knik Arm tributaries, and Susitna River tributaries that are accessible from the Parks Highway (Figure 1). In northern Cook Inlet, the most important chinook salmon, *Oncorhynchus tshawytscha*, fisheries occur in Willow Creek and the Little Susitna River; while the most important coho salmon, *O. kisutch*, fisheries occur on tributaries to the Knik Arm of Cook Inlet (the Little Susitna River, Cottonwood Creek drainage, and Big Lake drainage) and tributaries to the Susitna River (Willow, Little Willow, Caswell, and Sheep Creeks).

While the number of commercial fishermen remains fairly static because of limited-entry laws, the sport fishing effort has continued to increase along with the increase in population; consequently, these two user groups agreed to have management

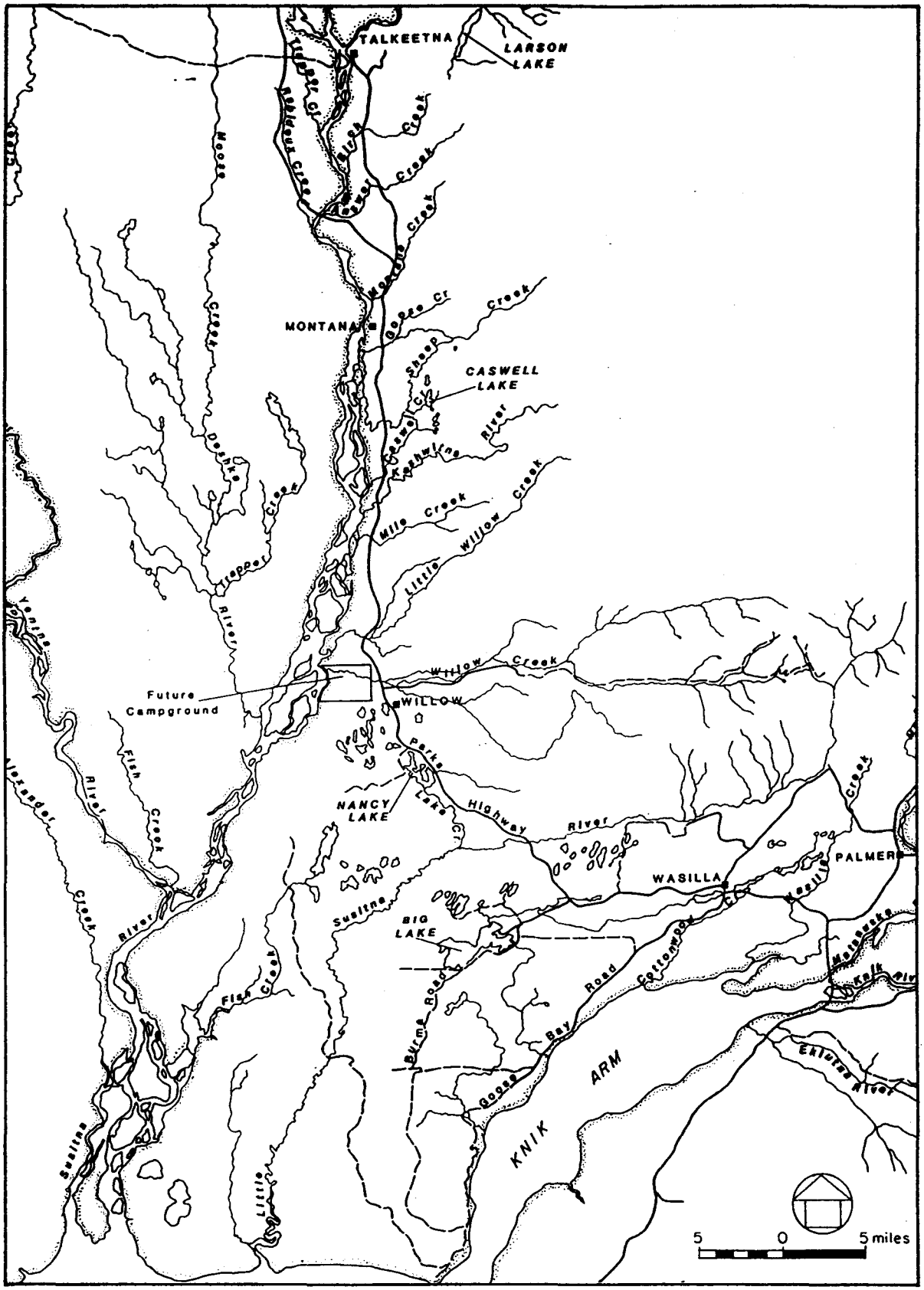

Figure 1. Popular northern Cook Inlet road-system sport fishing drainages.

(Sport Fish and Commercial Fisheries Divisions, Alaska Department of Fish and Game) prioritize the species of salmon each would target: sockeye salmon, *O. nerka* (Walbaum), pink salmon, *O. gorbuscha* (Walbaum), and chum salmon, *O. keta* (Walbaum), for commercial use, and chinook and coho salmon for sport use.

Sport fishing effort in the Cook Inlet area has been increasing dramatically (Mills 1985). As the fishing pressure in Kenai Peninsula drainages has increased, there has been some shift in effort to the less-crowded northern Cook Inlet River systems. Also, increased public access to the key northern Cook Inlet river systems has provided more opportunities for sport fishing. With this increased fishing effort, however, has come increasingly restrictive management to maintain adequate spawner escapement. A number of systems have been regulated as "weekend-only" sport fishing because the demand exceeds the availability of natural stocks.

Supplemental production of chinook and coho salmon by the Fisheries Rehabilitation, Enhancement and Development (FRED) Division is providing additional sport fishing opportunities in northern Cook Inlet. Two hatcheries, Big Lake and Fort Richardson, currently serve in augmenting the fishery by producing chinook and coho salmon fingerlings and smolts. Fingerlings released in underutilized lakes connected to anadromous streams take advantage of existing food supplies. The strategy of releasing smolts takes advantage of their ability to readily (in a matter of days) imprint to resident waters while migrating to sea. Because of their migratory nature, competition for food between planted smolts and other juvenile salmonids is minimal. With both fingerling and smolt releases, the returning adults will increase the number of fish available for sport fishermen. When the fish home to the imprinting sites, the collection of brood fish for egg takes will be more efficient. This project is based on a comprehensive approach to chinook and coho salmon enhancement in the northern Cook Inlet area. It will

not only provide eggs for hatchery production of fingerlings and smolts, but it will also facilitate the collection of life-history information that is necessary for the expansion of the enhancement program. Activities included in this project are (1) collection of samples for disease screening of brood stocks, (2) determination of the location of spawning areas, (3) description of spawning habitat characteristics, and (4) follow-up assessment of the contribution of stocked fish to the entire run.

OBJECTIVES

1. Increase sport fishing opportunities in the northern Cook Inlet area through supplemental production of chinook and coho salmon.

2. Collect stock abundance, distribution, life history, and disease information to support chinook and coho salmon enhancement.

3. Continue to develop and implement techniques to enhance chinook and coho salmon stocks.

4. Assess contributions to enhanced chinook and coho salmon sport fisheries.

MATERIALS AND METHODS

Juvenile Salmon Production

Eggs from both chinook and coho salmon were incubated at Fort Richardson Hatchery. After hatching and rearing, they were PLANTED into selected locations using transport equipment. Coho salmon eggs were incubated at the Big Lake Hatchery, and the fish were reared to fingerlings before they were planted using Big Lake Hatchery transport equipment.

To evaluate their survivals to smolt and adult life stages, fish at both facilities were marked with coded-wire tags. Marking procedures were conducted in accordance with the procedures described by Moberly et al. (1977). The number of fish to mark and the required number to recover was determined by FRED Region II biometrics staff. Usually the mark-recovery plan was designed for the smolt and/or adult life stage.

Juvenile salmon emigrating from Big Lake and Nancy Lake were captured daily during May and June using a modified fyke net mounted on a weir with a manually operated subsampler and live boxes.

The weirs used to collect smolts were funnel-shaped and constructed of 1.8-m-long by 1.3-cm-diameter conduit inserted in 5-cm x 5-cm x 4.7-mm aluminum angle 3.04 m long with holes 2.54 cm (center-to-center) apart. Weir sections were placed at an obtuse angle against the current and supported by 2-m x 6.35-cm aluminum conduit tripods. The throat of the modified fyke net was located at the apex of the funnel and led into the subsampler.

The subsampler had two holding boxes; an entrance to either one was controlled by a door that directed the current to the desired box. The net used to face the weir had 1.91-cm stretched-measure mesh. This was preceded by 7.6-m-long by 1.2-m-high lateral wings. The upper edges of the lateral wings were draped over the top of the weir, and the lower edges were extended upstream to form a 0.3-m apron with 2.54-cm-long, 112-g leads spaced at 25.4-cm intervals. The body had the same mesh size as the wings and was 1.22 x 1.22 m where the wings attached and 1.52 m long. Instead of leading into a typical fyke net throat, the body tapered to a 45.7-cm-diameter ring that served as the entrance and connector to the subsampler. The connection between the two outlets of the subsampler and the live boxes are 0.75 m long x 45.7 cm diameter and are constructed of 1.91-cm stretched-measure

mesh. Each 45.7-cm-diameter ring tapers to a 10.2- x 25.4-cm rectangular opening with 1.91-cm stretched-measure mesh to create a funnel. Each funnel is followed by another funnel leading to the live box.

The salmon smolt evaluation sampling schedule was designed to sample the nightly migration of the smolts; particular emphasis was placed on determining the proportion of hatchery-produced fish in the respective populations.

At Lake Creek, a tributary to the Little Susitna River and the outlet of Nancy Lake, smolts were individually hand-counted during the entire 6-h sampling period from 2100 to 0300 h. During the remaining 18 h, smolts were also individually hand-counted during a randomly selected 108-min period. During the remaining time, fish were allowed to pass freely through the weir. Fish caught during the evening and daytime sampling periods were anesthetized in a solution of 2.3 g of MS-222 and 3.0 g of $NaHCO_3$ in 45.5 liters of water, counted, and examined for marks. Scale samples were collected from both marked and unmarked fish, and size measurements were recorded. The sampling regimen at Fish Creek, below the outlet of Big Lake, was similar in design; however, during the 6-h nighttime period (2100-0300 h), fish were counted from a 10-min sample collected from every 30-min interval.

The smolt population sizes were estimated using a stratified sampling design presented by Cochran (1977). One night period stratum of Lake Creek data consisted of two adjacent (or consecutive) nightly periods (i.e., 2100-0300 day 1 + 2100-0300 day 2 = stratum), and a day-period stratum consisted of two adjacent day periods (i.e., 0300-2100 day 1 + 0300-2100 day 2 = stratum). One night-period stratum of Fish Creek data consisted of two adjacent 0.5-h periods (i.e. 2100-2130 + 2130-2200 = stratum). One day-period stratum at Fish Creek was determined the same as for Lake Creek.

The calculations used to estimate the hatchery contribution to the smolt population were determined from the proportion of hatchery-produced smolts in the smolt catches based on the following formulas:

$$\hat{T} = (H/N1)\ (m_3/n_3)$$

$$\hat{q} = (E/N1)\ (m_3/n_3)$$

where:

$\hat{T}$ = estimated proportion of hatchery smolts in the emigrating smolt population (i.e., H remaining as a proportion of H)

$\hat{q}$ = estimated hatchery-produced smolts in the smolt population as a proportion of the release (i.e., H remaining in E as a proportion of H)

H = number of hatchery-produced fish released

N1 = number of marked fish released

E = number of smolts caught

n_3 = number of smolts caught that were examined for marks

m_3 = number of marked smolts found

Variance formulas for each of the estimates were derived from Cochran (1977). After the population size and the proportion of hatchery-produced smolts were estimated, the number of hatchery-produced smolts and their survival rate was calculated.

All fish were placed into a holding box immediately after enumeration to recover before they were released. During each night and day sampling period, lengths (mm) and weights (g) from 20 fish were recorded, and seven scales from the "preferred area" were collected and mounted. In addition, all fin-clipped fish were measured and weighed, and scale samples were taken. Scales were placed on 7.62- x 2.54-cm micro slides and covered by another slide. Ages of the smolts were determined from the scales by using a Microfiche reader and age designations were recorded according to the European formula.

Chinook and Coho Salmon Adult Studies

Marked adult fish were recovered both at weirs and during a creel census. Each adipose-fin-clipped fish was handled according to sampling instructions provided by ADF&G and forwarded to the FRED Division Tag Lab for tag extraction, decoding, and identification.

Fish caught at weirs provided mark-recapture data, and information about run timing and escapement as well as age-length-weight (AWL) data. In addition, fish were collected for egg takes. Sampling procedures of ADF&G were followed for AWL data collection.

A weir for adult chinook salmon located at the mouth of Deception Creek (a tributary to Willow Creek) was operational from 7 July through 7 August 1986 (Figure 2). A weir for adult coho salmon on Fish Creek (located approximately 1.6 km downstream from the outlet water-level control structure of Big Lake) was operational from 10 July through 26 August 1986. On Meadow Creek (tributary to Big Lake) Big Lake Hatchery personnel operated a weir for coho salmon brood-stock collection. The operation and design of the Meadow Creek weir was described by Clevenger (1986). At the Little Susitna River, Sport Fisheries Division personnel operated a weir to count the escapement of several species (Bentz 1986).

The weirs at Deception and Fish Creeks were designed specifically for those locations. Each weir was orientated to direct fish into a holding box for sampling. The holding boxes were located in the main channel where most fish migrated through the deepest part of the creek.

These weirs were constructed of 1.8-m-long x 1.3-cm-diameter conduit inserted through holes 2.54 cm apart in 3.04-m-long, 5- x 5-cm x 4.7-mm aluminum angle. Weir sections were supported by tripods constructed from 2-m-long x 6.35-cm-diameter aluminum

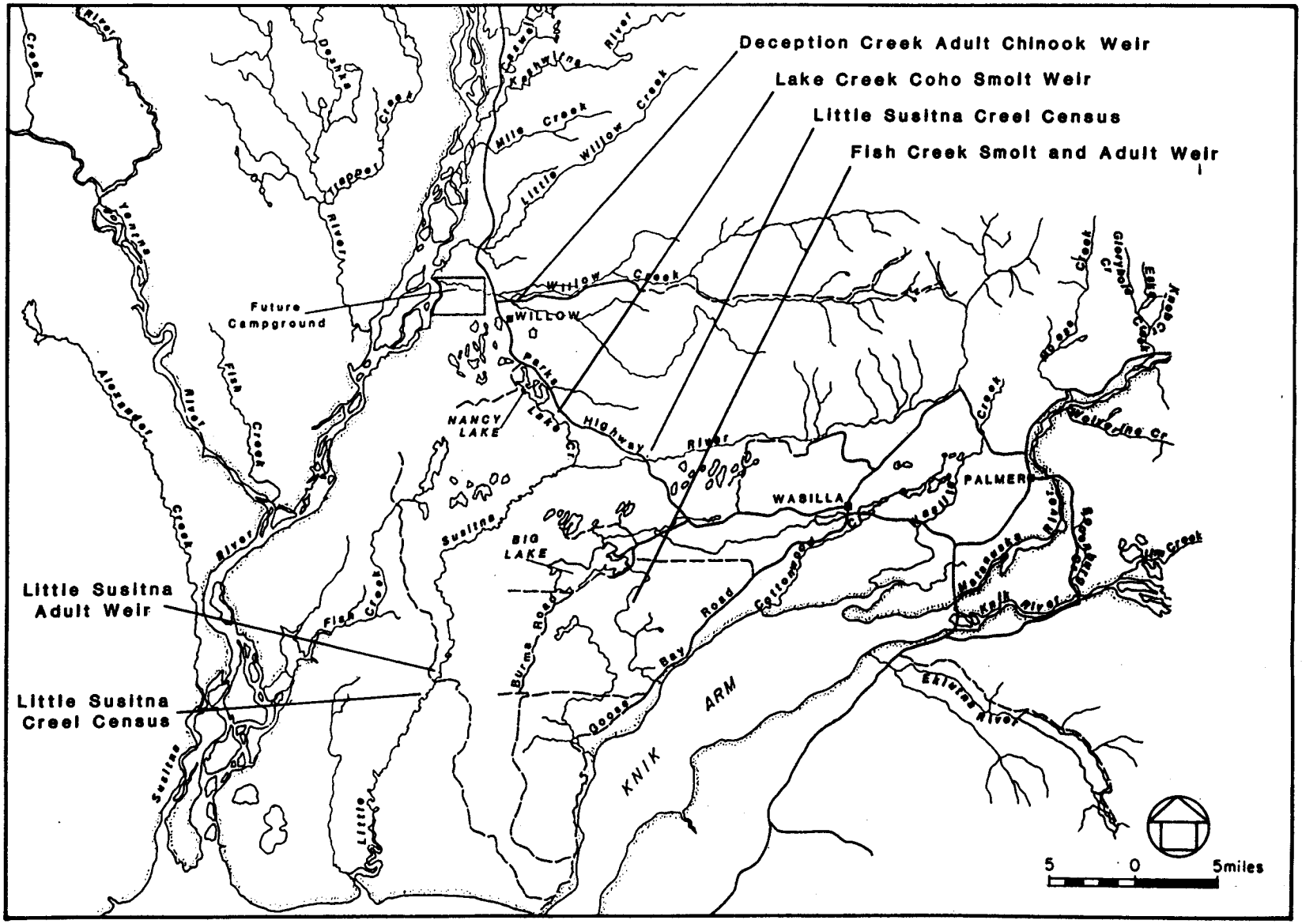

Figure 2. Geographical location of weirs and creel census locations.

conduit. A live box at each weir was also constructed from aluminum angle and conduit materials. Its dimensions were 2.45 long x 1.22 wide x 0.91 m high. The floor and lids were of marine plywood painted light green.

The creel census for chinook salmon and coho salmon was operated by Sport Fish Division personnel at the confluence of Willow Creek with the Susitna River and at selected locations along the Little Susitna River (Hepler and Bentz 1986).

Estimation of hatchery contributions to the adult populations was determined according to the formulas suggested by Kit Rawson (personal communication, 1986):

$$\text{contribution estimation} = (m)(E_1)(E_2)$$

$$\text{variance of contribution estimation} = (m)(E_1^2)(E_2^2)$$

$$\text{standard deviation of estimation} = \sqrt{(m)(E_1)(E_2)}$$

where:

E_1 = number released/number marked

E_2 = run size/number examined

m = marks recovered

Chinook and Coho Salmon Egg Takes

The Fish Culture Manual (1983) outlines the basic procedures for collection and spawning of fish; however, the actual collection of brood fish is different for each species and from drainage to drainage as well as within a drainage. Aside from adult coho salmon brood-stock collection at Big Lake Hatchery where a weir directs fish through a fishpass to a holding area, the egg-take

sites in northern Cook Inlet are remote, and fish must be collected with the use of nets. All fish were spawned on site; eggs were fertilized, water hardened, and transported to a facility. Collection of fish was done by hauling a floating, stretched gillnet downstream towards a lower one. Gillnets of #15 green nylon monofilament were 9.1 m long by 1.8 m deep and had 76-mm-square mesh; a vertical line at each end was tied to the float line, webbing, and lead line. The poly float line was 38 mm in diameter and had eye loops on all four corners and 76- by 127-mm floats spaced at 380-mm intervals. The lead line was single; its lead core was rated at 0.7kg/m. Lead and vertical lines were tied every 152 mm.

During previous years, the survival of chinook salmon eggs taken from the Deshka River broodstock has been poorer than desired. During 1986 a simple experiment was devised to evaluate the effect of water temperature in the transport container on the survival of these eggs.

The chinook salmon egg take on the Deshka River occurred from 28 July through 1 August. Stream water temperatures ranged from 12° to 16°C. Six lots totaling 248,892 eggs were taken. For the first two lots of 15,020 and 48,600 eggs, the egg-take procedures and egg-handling and transport techniques were identical to those of previous years. The next 4 lots of 67,033, 27,904, 53,968, and 36,367 eggs were treated identically, except that after egg fertilization, rinsing, and pouring eggs into a 37.80-liter container of water, ice was added to the transport container to reduce the water temperature. The water was tempered from between 13° and 15°C, to 3.5° and 5°C. Eggs were never added to precooled water. Within about 2-3 hours, the water temperature in the transport container was about 5.5°C. More ice was then added to containers for the 2- to 3-hour transport, since ambient air temperatures varied between 14° and 15°C. Upon arrival at Fort Richardson Hatchery, the water temperatures in the container ranged between 4° and 5.5°C.

No ice was added to the water to control transport water temperatures for coho salmon eggs because ambient temperatures ranged between -1° and 5.5°C.

Disease History

Establishment of a disease history is required for prospective hatchery brood-stock candidates, according to Title 5 of the Alaska Administrative Code. The pathology section of FRED Division analyzes fish tissue samples for parasites, bacteria, and viruses. Collection guidelines for bacterial (1982) and viral (1983) specimens were followed to collect tissue samples from adult salmon in spawning condition or spawned-out fish that were caught using techniques as outlined by ADF&G (1983).

RESULTS

Chinook and coho salmon have been stocked in selected drainages of northern Cook Inlet since 1976 (Table 1). During 1986 studies were implemented to assess the results of recent releases. These studies concerned both the juvenile and adult lifestages.

Juvenile Coho Salmon

During 1986 studies to estimate the coho salmon smolt population in the Big Lake drainage commenced 5 May and ended 30 June. An estimated 105,681 coho salmon smolts migrated through Fish Creek weir (Table 2). Of 13,238 fish observed to determine if their adipose fin had been excised, 58 were marked. An estimated 15,744 age-2.0 and 22,627 age-3.0 fish were of hatchery origin. Hatchery-produced smolts comprised 36% of the migrants, and the estimated survival rates from stocked fingerlings to age-2.0 and 3.0 smolts were 1.6% and 1.4%, respectively.

Table 1. Fish released from Big Lake and Fort Richardson hatcheries in northern Cook Inlet waters.

Hatchery	Species	Brood year	Eggs incubated: Origin	Eggs incubated: Number	Fish released: Year	Fish released: Location	Fish released: Lifestage	Fish released: Number	Number marked	Dominant return year
Big Lake	Sockeye	1975	Big L.	180,300	1976	Big L.	fingerling	71,168	0	1979
Big Lake	Sockeye	1976	Big L.	10,034,013[a/]	1977	Big L.	fingerling	7,686,382	72,673	1980
Big Lake	Coho		Big L.	78,983		Big L.	fingerling	40,673	23,852	1980
Big Lake	Chinook		Crooked Cr.	100,300		Big L.	fingerling	56,055	0	****
Big Lake	Sockeye	1977	Big L.	8,748,867[b/]	1978	Big L.	fingerling	5,739,010	66,153	1981
Big Lake	Sockeye		Nancy L.	2,432,170		Nancy L.	fingerling	2,102,369	30,457	1981
Big Lake	Kokanee		Hidden L.	406,878		Hidden L.	fingerling	301,279	29,951	****
Big Lake	Coho		Big L.	589,623[c/]		Big L.	fingerling	101,081	40,959	1981
Big Lake	Coho		Big L.			Cottonwood L.	fingerling	317,694	32,064	1981
Big Lake	Sockeye	1978	Big L.	9,832,726[d/]	1979	Big L.	fingerling	0	0	1982
Big Lake	Sockeye		Nancy L.	549,187[d/]		Nancy L.	fingerling	0	0	1982
Big Lake	Coho		Big L.	842,238[c/]		Big L.	fingerling	383,295	20,218	1982
Big Lake						Cottonwood L.	fingerling	246,762	19,992	1982
Big Lake	Sockeye	1979	Big L.	5,053,808	1980	Big L.	fingerling	806,047[e/]	0	1983
Big Lake	Sockeye		Nancy L.	991,848		Nancy L.	fingerling	681,699	0	1983
Big Lake	Coho		Big L.	927,708[f/]		Big L.	fingerling	99,736	0	1983
Big Lake						Big L.	fingerling	351,151	22,337	1983
Big Lake						Cottonwood L.	fingerling	154,991	15,000	1983
Big Lake						Cottonwood L.	fingerling	155,004	15,000	1983
Big Lake	Sockeye	1980	Big L.	4,699,733	1981	Big L.	fingerling	3,967,941	0	1984
Big Lake	Sockeye		Nancy L.	755,851		Nancy L.	fingerling	738,779	0	1984
Big Lake	Coho		Big L.	543,081[f/]		Big L.	fingerling	118,071	13,072	1984
Big Lake						Cottonwood L.	fingerling	179,117	18,450	1984
Big Lake						Cottonwood L.	fingerling	181,658	18,500	1984
Big Lake	Sockeye	1981	Big L.	5,662,004	1982	Big L.	fingerling	4,623,356	0	1985
Big Lake	Sockeye		Nancy L.	1,692,017		Nancy L.	fingerling	1,018,512	0	1985
Big Lake	Coho		Big L.	1,242,993[f/]		Big L.	fingerling	585,548	23,085	1985
Big Lake						Cottonwood L.	fingerling	364,911	86,850	1985
Big Lake			Little Susitna R.	3,113	1982	Little Susitna R.	fingerling	2,950	0	1985

-continued-

Table 1. Fish released from Big Lake and Fort Richardson hatcheries in northern Cook Inlet waters (continued).

Big Lake	Sockeye	1982	Big L.	8,624,662	1983	Big L.	fingerling	6,601,409	0	1986
Big Lake			Nancy L.	2,921,451[f/]		Nancy L.	fingerling	1,114,528	0	1986
Big Lake	Coho		Big L.	2,782,857[f/]		Big L.	fingerling	1,612,337	21,607	1986
Big Lake			Cottonwood L.	232,332		Cottonwood L.	fingerling	368,022	21,917	1986
Big Lake			Little Susitna R.	500,775		Little Susitna R.	fingerling	216,508	20,835	1986
Big Lake	Sockeye	1983	Big L.	9,294,426	1984	Big L.	fingerling	7,362,000	0	1987
Big Lake	Coho		Big L.	1,664,295		Big L.	fingerling	986,552	10,000	1987
Big Lake			Cottonwood L.	25,796		Cottonwood L.	fingerling	372,318	10,000	1987
Big Lake			Little Susitna R.	547,214		Little Susitna R.	fingerling	426,216	10,000	1987
Big Lake	Sockeye	1984	Big L.	16,210,000	1985	Big L.	fingerling	12,430,000	18,835	1988
Big Lake	Coho		Big L.	3,082,000		Big L.	fingerling	1,053,000	10,000	1988
Big Lake			Cottonwood L.	35,000		Cottonwood L.	fingerling	336,000	10,000	1988
Big Lake			Little Susitna R.	1,350,000		Little Susitna R.	fingerling	1,225,000	10,000	1988
Big Lake	Sockeye	1985	Big L.	20,100,000	1986	Big L.	fingerling	14,529,683	18,281	1989
Big Lake	Coho		Big L.	3,454,150		Big L.	fingerling	2,354,725	13,497	1989
Big Lake			Cottonwood L.	0		Cottonwood L.	fingerling	315,881	0	1989
Big Lake			Little Susitna R.	352,000		Little Susitna R.	fingerling	316,270	10,300	1989
Ft. Rich	Chinook	1983	Willow Cr.	307,000	1985	Willow Cr.	smolt[h/]	101,256	8,152	1989
Ft. Rich	Coho		Little Susitna R.	56,000	1985	Little Susitna R.	smolt	54,000	12,000	1986
Ft. Rich	King	1984	Willow Cr.	759,000	1985	Willow Cr.	smolt	433,133	22,123	1989
Ft. Rich						Prince William Sound	smolt	147,681	18,454	1989
Ft. Rich	Coho	1984	Little Susitna R.	594,000	1986	Little Susitna R.	smolt	474,106	23,217	1987
Ft. Rich	Chinook	1985	Willow Cr.	377,000	1986	Willow Cr.	smolt	325,304	28,188	1990
Ft. Rich			Deshka R.	458,200	1986	Prince William Sound	smolt			
Ft. Rich	Coho	1985	Little Susitna R.	552,000	1987					
Ft. Rich			Caswell Cr.	60,000	1987					

a/ An egg plant of 500,000 into Lucille Creek, a tributary of Meadow Creek, failed.
b/ Includes 4 million Tustumena eggs fertilized with Big Lake males.
c/ Big Lake coho salmon used to stock Cottonwood system until respective brood source is developed.
d/ All destroyed due to infectious hematopoietic necrosis virus (IHNV).
e/ The large majority destroyed due to IHNV. Survival of remainders is likely low due to environmental conditions.
f/ Big Lake coho salmon used to stock Cottonwood system. Two different size stocked

Table 2. Average sizes, condition factors, and age-class composition of marked and unmarked coho salmon smolts from Fish and Lake Creeks, 1986.

Creek weir	Sample size	Mark status	Age	Length (mm)	S.D.	Weight (gm)	S.D.	Condition factor	Percent composition
Fish Cr.	95	Unmark	1.0	105	9	13	3	1.15	18
	340	Unmark	2.0	130	13	22	7	1.02	63
	20	Marked	2.0	137	11	26	6	1.02	34
	103	Unmark	3.0	154	13	36	11	0.98	19
	38	Marked	3.0	157	10	38	9	0.97	66
Lake Cr.	400	Unmark	1.0	116	10	14	6	0.90	71
	323	Marked	1.0	114	10	13	4	0.86	85
	149	Unmark	2.0	123	10	18	5	0.92	26
	56	Marked	2.0	120	8	14	3	0.84	15
	15	Unmark	3.0	156	18	40	16	0.99	3
	1	Marked	3.0	157	--	33	--	0.85	--

Of 540 readable scales, 18% were age 1.0, 65% were age 2.0, and 19% were age 3.0 (Table 2); mean lengths (mm) and weights (g) were 105 mm and 13 g, 130 mm and 22 g, and 154 mm and 36 g for each age-class, respectively. No age-1.0 marked smolts were found among fish used for scale samples, but marked age-2.0 and 3.0 smolts averaged 137 mm and 26 g and 157 mm and 38 g, respectively.

At Nancy Lake, which drains into the Little Susitna River via Lake Creek, coho salmon smolts and fingerlings were stocked. Smolts were stocked in May 1986 and fingerlings in May 1984. Based on the stratified sampling design, an estimated 497,080 coho salmon smolts migrated from Nancy Lake between 6 May and 27 June 1986 (Table 3).

A total of 218,021 fish was examined for marks; of these, 11,257 were marked. Based on the numbers and proportions of marked smolts in the sample, an estimated 609,550 coho salmon smolts migrated from Nancy Lake. Of these, an estimated 164,026 were from the fingerling plant, while an estimated 445,524 were from the smolt plant (Table 3). Hatchery-produced fish comprised 100% of the population: 63% from smolts released from Fort Richardson Hatchery and 27% from fingerlings released from Big Lake Hatchery. The survival rate from stocked fingerling to smolt was estimated at 38%, and an estimated 94% of the smolts migrated from the stocking location through the weir.

In 1986 ages of 549 unmarked and 378 marked coho salmon smolts from Lake Creek were determined from their scales (Table 4). Age-1.0 unmarked smolts averaged 116 mm long and weighed 14 g, while marked smolts were 114 mm long and weighed 13 g. Unmarked age-2.0 smolts were 123 mm long and weighed 18 g; marked age-2.0 smolts were 120 mm long and weighed 14 g.

Table 3. Coho salmon smolt weir operation and smolt population estimates in Fish and Lake Creeks, 1986.

Weir Location	Drainage	Date of operation	Mid-point of migration	Estimated Population	95% confidence limit	
				Number	Lower	Upper
Fish Creek	Big Lake	5 May - 30 Jun	8 Jun	105,681	94,354	117,008
Lake Creek	Little Susitna R.	6 May - 27 Jun	5 Jun	497,080	304,051	680,109

Table 4. Contribution of hatchery-produced coho salmon to the smolt populations in Fish and Lake Creeks, 1986.

Location	Stocking lifestage	Smolt age	Estimated population of hatchery fish			Estimated percentage of population	Estimated percent survival
			Number	95% confidence limit Lower	Upper		
Fish Creek	fingerling	2.0	15,744	12,223	19,265	15	1.6
	fingerling	3.0	22,627	18,959	26,295	21	1.4
		Total	38,371	31,182	45,560	36	
Lake Creek	fingerling	2.0	164,026	160,034	168,018	27	38
	smolt	1.0	445,524	440,970	450,078	63	94
		Total	609,550	601,004	618,096	90	

Adult Chinook Salmon Studies

Chinook salmon smolts were first released into Deception Creek, (tributary to Willow Creek) in 1985; of 534,389 released, 30,275 were marked. The average year-class composition of the Willow Creek chinook salmon stock has been 15% age 1.2, 21% age 1.3, and 64% age 1.4; and typically, no age-1.1 "jacks" have been observed. Nevertheless, a weir was fished in Deception Creek from 7 July through 7 August 1986 to determine if age-0.1 jacks were present in the escapement. A total of 521 chinook salmon migrated past the Deception Creek weir; of these, 214 were the size of jacks. Of 121 jack-sized chinook salmon examined, 5 were marked with adipose-fin clips, so the estimated hatchery contribution to the jack population was 72% of the escapement into Deception Creek. During a Sport Fish Division creel census, only a few jacks were caught; some had been marked (R. Bentz, unpublished data, 1986).

Adult Coho Salmon Studies

The weir to count adult coho salmon at Fish Creek was operational from 14 July through 26 August. A total of 816 fish was enumerated; however, on 26 August an estimated 1,350 fish were holding in pools upstream (1-2 km) from the intertidal area (downstream from the weir). Consequently, the estimated run strength was 2,166 fish. It appeared that most of the estimated 1,350 fish had moved into Big Lake by 8 September. Between 12 and 16 September approximately 1,200 fish had moved into the holding area at Big Lake Hatchery on Meadow Creek.

During egg takes, 2,005 fish were examined and 23 marked fish were observed. An estimated 1,854 (range: 1,486-2,240) fish, or 86%, were of hatchery origin. Approximately 0.11% of the fingerlings planted returned to the stream as adults; others were caught in various fisheries. The age-class distribution for ages 1.1, 2.1, and 3.1 were 10%, 72%, and 18%, respectively.

Marked adult coho salmon in the Little Susitna River were noted at Sport Fish Division's escapement weir and during creel censuses at the lower Little Susitna River and the Ship Creek boat launching ramp. From a total of 4,359 fish examined, 35 marked fish were observed; of these, 21 heads were collected for coded-wire tag recovery. Results of the tag reading indicates that adults were represented from both fingerling and smolt plants. The estimated adult contribution from the smolt release was 367 fish (range 302-432), while that from the fingerling release was 79 fish (range 33-125). The estimated survival from the smolt and fingerling release, was 0.7% and 0.4%, respectively, while the hatchery contributions from these comprised 3.3% and 0.7%, respectively, of the sport catch.

Chinook and Coho Salmon Egg Takes

The 1986 egg take scheduled at Deception Creek (Willow Creek) to obtain chinook salmon eggs for incubation and rearing at Fort Richardson Hatchery was cancelled because scheduled construction activities to upgrade the water supply system would have interrupted the water supply. The amount of water available would have been adequate for incubation to the eyed-egg stage, but not enough for complete incubation or rearing; consequently, the only chinook salmon eggs taken were from the Deshka River. At the eyed-egg stage, these eggs were transferred to Esther Hatchery in Prince William Sound for rearing to smolts for selected enhancement projects in the Sound.

As chinook salmon were handled at the Deception Creek weir to find marked fish, it was determined that fish were ripe from 21 to 29 July. This corresponds with previous egg-take dates of 26 July 1983, 25 July 1984, and 24 July 1985.

The survival of chinook salmon eggs taken from the Deshka River brood stock to the eyed-egg stage was 81% and 80%, respectively, for lots 1 and 2; this is similar to the approximately 80%

survivals of previous years (G. Wall, unpublished data, 1983-1985). During coho salmon egg takes in late fall when stream water temperatures were from 1° to 5°C, approximately 95% of the eggs survived to the eyed stage at both Big Lake Hatchery (D. Moore, unpublished data) and Fort Richardson Hatchery (Wall 1986). The survival rates for eggs in lots 3-6 to the eyed stage averaged 96.5% and ranged from 95% to 99%.

The 1986 Little Susitna River coho salmon egg take was hampered by high water and a smaller than normal escapement. Flooding occurred twice during the coho salmon spawning period. The first high-water period started 20 September and continued through 27 September. It appeared from visual observation and test netting during 13-19 September that the peak of spawning probably occurred during the first high-water period. Water level receded by 29 September. The 13.3-km reach from Welch Road to Mahoney's Bridge typically receives the highest concentration of coho salmon spawners in the 183-km Little Susitna River corridor. Egg takes commenced here on 29 September but ended on 3 October because of lack of spawners. Approximately 495,000 eggs were taken. Other reaches of the drainage were scheduled for egg takes during 3-10 October, but efforts were thwarted by another week of high-water following heavy rains.

At Nancy Lake in the Little Susitna River drainage, egg takes were also planned at two new candidate locations where the first adult returns were expected from coho salmon fingerlings and smolts that had been stocked. Historically, both locations have been void of coho salmon spawners. Approximately 20 and 50 fish were observed at the respective locations. By seining in the stream mouths, 18 fish (3 females) were captured for egg-take purposes. High water resulting from a 100-year area-wide flood prevented us from recovering any adult salmon in the streams above the mouths.

A total of 2.8 million coho salmon eggs was taken from the Big Lake drainage at the Big Lake Hatchery brood-stock capture area on Meadow Creek. Fingerlings and smolts resulting from this egg take will be used to supplement Knik Arm tributaries.

Disease History

Northern Cook Inlet salmon disease histories from current and prospective brood sources are presented in Table 5. Drainages targeted for disease screening in 1986 were Little Willow Creek, a drainage that is intersected by the Parks Highway, and Alexander Creek, a lower "west-side" Susitna River tributary accessible by plane or boat. Approximately 60 kidney and hindgut specimens were collected from Little Willow Creek coho salmon, and about 70 kidney, hindgut, and ovarian-fluid samples were collected from Alexander Creek chinook salmon; results are pending.

DISCUSSION

FRED Division efforts in the northern Cook Inlet area are designed to augment existing chinook salmon and coho salmon runs. These efforts have followed the sequence of programs according to the fish species and drainage prioritization as presented in the Plan for Supplemental Production of Salmon and Steelhead for Cook Inlet Recreational Fisheries (ADF&G, 1981).

The most popular sport fisheries for coho salmon in road-system streams in northern Cook Inlet are the Knik Arm tributaries of Jim Creek, a "7-day weekly" fishery; Rabbit Slough, Cottonwood Creek, Fish Creek, all "weekend only" fisheries; and Little Susitna River, the most intensive 7-day fishery. Angling effort on tributaries accessible from the Parks Highway on the east side of the Susitna River is distributed among Willow, Little Willow, Caswell, Sheep, Goose, and Montana Creeks; all of these are open to fishing every day of the week. Coho salmon enhancement

Table 5. Summary of disease history of salmon brood stocks in northern Cook Inlet.

Species	Brood stock	Lifestage	Sampling location	Disease Organism: IHN No. positive	IHN No. samples	BKD No. positive	BKD No. samples	Furunculosis No. positive	Furunculosis No. samples	Pseudomonas No. positive	Pseudomonas No. samples
Sockeye	Fish Creek	adult	Big Lake H.	174	310						
Sockeye	Fish Creek	adult	Fish Creek	22	64						
Sockeye	Fish Creek	fry	Big Lake H.	2	74	0	10	0	10		
Sockeye	Larson Lake	adult	Larson Lake	8	70						
Coho	Fish Creek	fry	Big Lake H.	4	30	0	10	2	22	2	12
Coho	Fish Creek	adult	Fish Creek			0	100	0	100		
Coho	Fish Creek	fry	Eklutna H.			0	20	0	20		
Coho	Cttnwood Cr.	smolt	Cttnwood Cr.			0	55				
Coho	Little Su. R.	adult	Little Su. R.			0	64				
Coho	Deshka R.	adult	Deshka			0	65	2	65		
Coho	Caswell Cr.	adult	Caswell Cr.			0	64	0	64		
Coho	Sunshine Cr.	fry	Sunshine Cr.			0	62	0	62		
Coho	Rabideaux Cr.	fry	Rabideaux Cr.			0	100	0	100		
Coho	Rabideaux Cr.	adult	Rabideaux Cr.			0	55	0	55		
Coho	Birch Cr.	fry	Birch Cr.			0	60	0	60		
Coho	Clear Cr.	adult	Clear Cr.			0	55	0	55		
Coho	Little Willow Cr.	adult	Little Willow Cr.			Results Pending					
Chinook	Willow Cr.	adult	Willow Cr.	0	61	0	63	0	63		
Chinook	Prairie Cr.	adult	Prairie Cr.	0	66	0	94	52	94		
Chinook	Deshka R.	adult	Deshka R.	0	100	0	63	0	63		
Chinook	Lake Cr.	adult	Lake Cr.	0	70	0	83	48	83		
Chinook	Montana Cr.	adult	Montana Cr.			0	31	6	36		
Chinook	Montana Cr.	adult	Montana Cr.	0	54	0	60	20	60		
Chinook	Little Su. R.	adult	Little Su. R.	0	76	0	67	5	67		
Chinook	Alexander Cr.	adult	Alexander Cr.	Results pending		Results pending		Results pending			
Pink	Willow Cr.	adult	Willow Cr.			0	20				
Chum	Willow Cr.	adult	Willow Cr.			0	60				
Chum	Little Su. R.	adult	Little Su. R.			0	60				

projects in northern Cook Inlet are presently geared for the Little Susitna River, Cottonwood Creek, and Fish Creek that drain into the Knik Arm, and Caswell Creek that drains into the Susitna River. More supplemental Knik Arm coho salmon releases into Rabbit Slough and Jim Creek are scheduled to begin in either 1 or 2 years, depending on survival and growth of eggs and juveniles resulting from this year's egg takes. Presently, the Fish Creek coho salmon brood stock is being developed as the donor stock for Knik Arm tributaries, except the Little Susitna River where the in-system brood stock is being used. Along the Parks Highway, the Caswell Creek enhancement project for coho salmon has been hampered by few or inaccessible brood stocks. As a contingency, however, an egg take from the Willow Creek brood stock is scheduled for next year. If the Willow Creek brood stock develops as hoped, this source could become a universal donor for "east side" Susitna River tributaries from Willow Creek to Montana Creek.

Chinook salmon sport fishery enhancement has been limited to Willow Creek where smolts have been stocked. Eggs have also been taken and incubated from the Deshka River. These juveniles, however, have been used as donors to support or create sport fisheries in Prince William Sound. In 1987 two additional egg takes for chinook salmon in northern Cook Inlet are scheduled in the Little Susitna River and Montana Creek; smolts produced from these egg takes will be stocked into their respective drainages.

Assessment of hatchery returns of adult chinook salmon and coho salmon in northern Cook Inlet is dependent on a variety of information collection systems. The data collection was coordinated between Sport Fish Division and FRED Division using creel censuses, escapement weirs, and egg takes for chinook salmon at Willow Creek and coho salmon at the Little Susitna River. In the Big Lake drainage, coho salmon were collected at an escapement weir and during the egg take in order to gather data for hatchery contribution estimates.

At Willow Creek, only age-0.1 chinook salmon "jacks" of hatchery origin were expected in 1986. Of those fish that migrated past the Deception Creek weir, 11% were jacks; of these, an estimated 72% were hatchery-produced. If all year classes survive in the expected proportions to these age-0.1 jacks and the age-class composition of hatchery-produced fish is the same as their parent stock, the hatchery contribution to the chinook salmon run during the next 3 years will be excellent.

Because the age-class composition of age-1.2, 1.3, and 1.4 chinook salmon in Willow Creek is 13%, 19%, and 57%, respectively, the greatest contribution will be in 1989. Some returning adult chinook salmon may be intercepted by a commercial fishery, but the hatchery-produced fish should be intercepted at the same rate as all Willow Creek chinook salmon.

Returning coho salmon in the Little Susitna River were examined for marks at the escapement weir and in the creel census. The estimated hatchery contribution to the instream return was 4%, or 350 fish. These originated from small releases because there had been an approximate nine-fold increase in the numbers of smolts stocked. Creel census and weir counts conducted by Sport Fish Division will continue in 1987, and returning fish will be examined for marks. Because the Nancy Lake coho salmon smolt migration in 1986 was about eight times greater than in 1985 (Chlupach 1986), the hatchery contribution in the fishery will also increase.

During 1986 approximately 1.0 million smolts migrated from Big Lake. Of these, 900,000 were sockeye salmon and 100,000 were coho salmon (Chlupach 1986). There is some unprecedented evidence that the large numbers of sockeye salmon smolts may be suppressing the number of coho salmon smolts; i.e., (1) the low smolt survivals of stocked coho salmon fingerlings (1.5%), and (2) the appearance of an increased proportion of age-2.0 and 3.0 coho salmon smolts (Chlupach 1986). It is hoped that future smolt studies will determine the validity of this evidence. If it is

determined that juvenile sockeye salmon in Big Lake may suppress the survival of juvenile coho salmon, a decision must be made for the stocking strategy that will achieve the optimal benefit for one or both species.

Thus far, results indicate that chinook salmon and coho salmon smolt and fingerling enhancement programs are making a positive contribution to the sport fish user group. Actual contributions have been small, but the forecasts are highly optimistic. Since the major and potential donor brood stocks have been screened for disease, implementation of a more comprehensive program is now possible (Chlupach 1985). In the northern Cook Inlet area, all the major tributaries to Knik Arm (Jim Creek, Rabbit Slough, Cottonwood Creek, Fish Creek and the Little Susitna River) will be supplemented with coho salmon fingerlings or smolts. The development of a universal east-side Susitna River tributary coho salmon brood stock is anticipated for smolt supplementation of drainages from Willow Creek to Montana Creek. With chinook salmon egg takes at Willow Creek, Little Susitna River, and Montana Creek, these most heavily fished northern Cook Inlet road-system drainages will soon be stocked with smolts. In addition, the Deshka River chinook salmon egg takes will provide a continuation of sport fishery enhancement programs in Prince William Sound. Table 6 summarizes the scheduled egg takes for 1987.

CONCLUSIONS

Sport fishing opportunities have been increased in the northern Cook Inlet area through supplemental production of chinook and coho salmon, as evidenced by the following facts:

1. During 1986, an estimated 86% of the coho salmon returning to Fish Creek were of hatchery origin.

Table 6. Egg takes scheduled in northern Cook Inlet in 1987.

Incubation facility	Species	Egg Take source	Estimated no. eggs (millions)	Enhancement	
				Location	Area
Fort Richardson	Chinook	Deskha R.	0.16	Valdez	Prince William Sound
Fort Richardson	Chinook	Deshka R.	0.10	Logging Camp Cr.	Prince William Sound
Fort Richardson	Chinook	Deshka R.	0.10	Caswell Cr.	Northern Cook Inlet
Fort Richardson	Chinook	Little Su. R.	0.20	Little Su. R.	Northern Cook Inlet
Fort Richardson	Chinook	Montana Cr.	0.10	Montana Cr.	Northern Cook Inlet
Fort Richardson	Chinook	Willow Cr.	0.40	Willow Cr.	Northern Cook Inlet
Fort Richardson	Coho	Little Su. R.	0.30	Little Su. R.	Northern Cook Inlet
Fort Richardson	Coho	Caswell Cr.	0.20	Caswell Cr.	Northern Cook Inlet
Big Lake	Coho	Fish Cr.	4.00	Knik Arm Tribs.	Northern Cook Inlet
Big Lake	Coho	Little Su. R.	2.00	Little Su. R.	Northern Cook Inlet

2. Hatchery-produced fish comprised an estimated 4% of the harvest in the Little Susitna River.

3. Large numbers of hatchery-produced smolts migrated from Nancy Lake (tributary to the Little Susitna River) in 1986. These data suggest that adult coho salmon returning to the Little Susitna River in 1987 will include a substantial proportion of hatchery-produced fish.

4. An estimated 72% of the age-1.1 and 0.1 "jacks" in Deception Creek (tributary to Willow Creek) were of hatchery origin. These contributed little to the catch in 1986; however, based on the age-class composition, these data suggest that substantial contributions will be made during 1987-1989.

To improve enhancement opportunities, additional information was collected during 1986 about the relative abundance, distribution and run timing. Tissue samples were collected from candidate brood stocks to learn about the incidence of disease for Little Willow Creek coho salmon and Montana and Alexander Creeks and Little Susitna River chinook salmon.

New techniques were evaluated to improve egg transport techniques and increase the survival rate of eggs taken.

RECOMMENDATIONS

Chinook Salmon

1. Continue to take chinook salmon eggs and stock smolts in Willow Creek.

2. Continue to mark smolts released into Willow Creek to assess their survival and contribution as adults to the sport fishery.

3. Continue operations to recover marked adults at a weir and during the creel census at Willow Creek to assess contributions of hatchery fish.

4. Continue the egg take at Deshka River to support enhancement programs outside northern Cook Inlet.

5. Utilize Fort Richardson Hatchery to incubate eggs and rear fingerlings to the smolt stage.

6. Begin a Little Susitna River enhancement project based on smolt releases.

7. Continue disease screening of chinook salmon stocks for new enhancement projects (e.g., collect ovarian-fluid samples from Alexander Creek and kidney, hindgut, and ovarian-fluid samples from Clear Creek brood stocks).

8. Continue to determine spawning escapement and spawning locations of chinook salmon in Montana, Prairie, and Lake Creeks as potential donors for future enhancement programs.

9. Initiate Clear Creek chinook salmon investigations to determine spawner distribution, run timing, and disease history.

Coho Salmon

1. Continue coho salmon egg takes from the Little Susitna River, Big Lake, and Cottonwood Lake drainages for incubation, rearing (fingerlings), and release from Big Lake Hatchery.

2. Continue coho salmon egg takes from the Little Susitna River and Caswell Lake drainages for incubation, rearing (smolt state), and release from Fort Richardson Hatchery.

3. Continue coded-wire tagging juvenile coho salmon prior to the releases from Fort Richardson and Big Lake Hatcheries.

4. Continue assessment of hatchery-produced fish contribution to the Big Lake and Little Susitna River smolt populations by operating the Fish Creek and Lake Creek weirs.

5. Continue to determine the escapement and distribution of spawning fish in the Little Susitna River, Big Lake, Cottonwood Lake, and Caswell Lake drainages.

6. Continue to collect tissue samples for disease-screening histories from tributaries to Yentna, Susitna, Talkeetna, and Chulitna Rivers.

7. Continue to recover marked adult fish at the Fish Creek weir to assess hatchery contribution.

8. Determine the feasibility of producing 30,000 to 60,000 smolts annually at Big Lake Hatchery for release in Knik Arm tributaries.

9. Investigate Jim Creek and Rabbit Slough drainages to determine optimal and accessible smolt release sites.

10. Continue to develop new or improved fish collection and egg transport techniques.

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